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The Effect of Alkaline solution-to-slag ratio on Permeability of Alkali Activated Slag Concrete

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1. Introduction

Features such as convenient moldability, good fire resistance, easy production, and high economic advantage have turned concrete into the best-known, most popular, and most widely used construction material. This growing use of concrete and cement and its expected impacts on environment and sustainable development highlights the importance of novel methods and technologies of concrete production. The use of alkali activated cements as the third generation of cementitious material (after lime and Portland cement) has a relatively long history.

Durability of concrete is one of its most important properties, since concrete is required to endure the design conditions throughout the entire life of structure. Chemical agents are among the factors that can reduce this durability.

This factor, permeability, is especially more importance for hydraulic structures and those that are situated in marine environment. Reducing the permeability of concrete can therefore improve its durability and prolong the service life of structures. Sodium hydroxide, potassium hydroxide, sodium carbonate or a combination of sodium-potassium hydroxide with sodium silicate or potassium silicate are the most commonly used activator compounds.

2. Materials and experimental work

In this study, the 28-day and 90-day compressive strengths of cubic samples were measured. Figure 1, which shows the 28-day and 90-day compressive strengths of samples, demonstrates the effect of A/S ratio on the compressive strength of samples.

As Figure 1 shows, as A/S ratio increases from 0.4 to 0.55, compressive strength first increases but then exhibits a slightly downward trend.

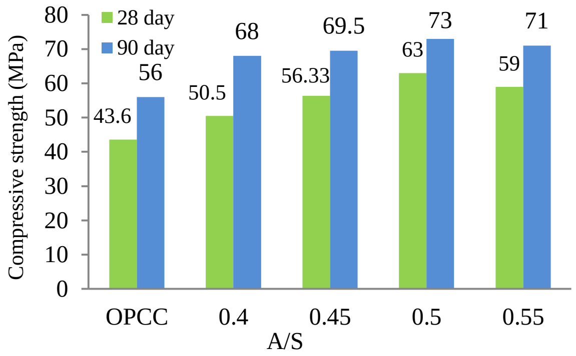

Fig 1. Effect of alkaline-solution to slag ratio on compressive strength

As Figure 2 shows, the increase in alkaline-solution/slag ratio has increased both short-term and total water absorption, but this increase has been marginal. Moreover, the results show that there is only a slight difference between short-term and total water absorption of AAS concretes with different A/S. It should also be mentioned that according to Iranian Code of Practice for Concrete Durability in the Persian Gulf and Omman Sea Region (PGOSR), the short-term water absorption reported for all alkaline-solution/slag ratios are suitable for ambient condition C.

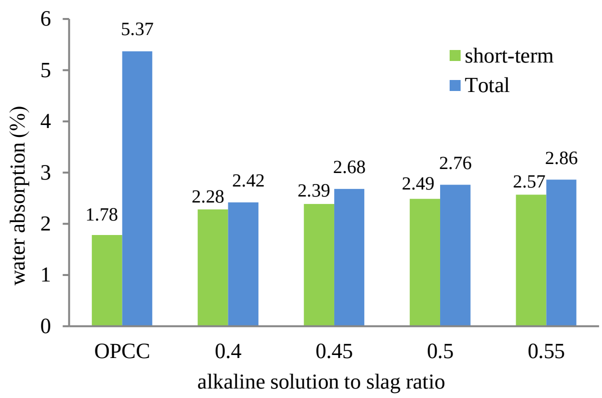

Fig 2. Short-term and total water absorption results

In this study, the rapid chloride permeability test (RCPT) was conducted in accordance with ASTM C1202 guidelines (Figure 3). To achieve a higher accuracy, the samples were tested in 20 minutes intervals.

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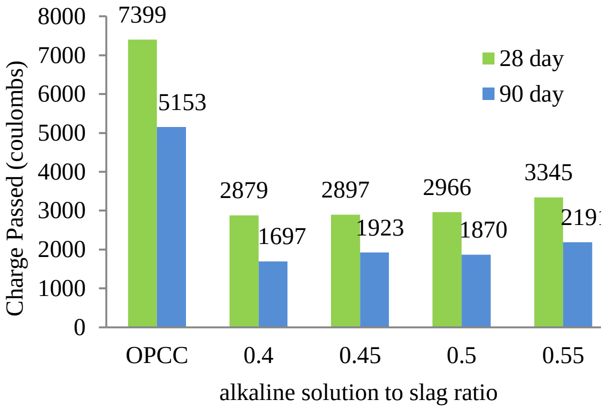

Fig 3. Results of RCPT

As Figure 3 shows, the increase of alkaline-solution/slag ratio has increased the quantity of passing electric charge in both 28-day and 90-day samples. This means that higher alkaline-solution/slag ratios have decreased the resistance of samples against penetration of chlorine ions.

In this subsection, the results of water impermeability test, Figure 4, conducted on 28-day samples in accordance with EN 12390-8 guidelines is presented. To clarify the effect of alkaline-solution to slag ratio on water penetration, the results of water impermeability test were is shown in Figure 4.

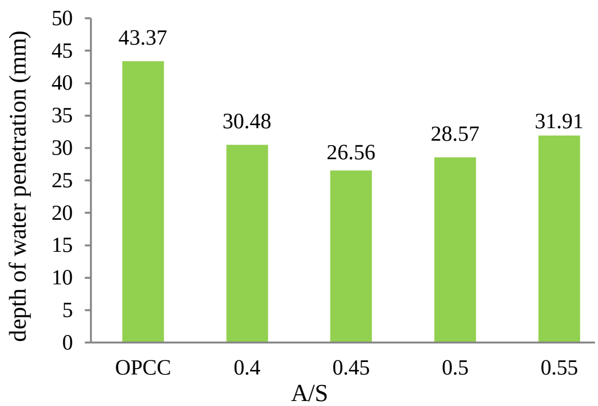

Fig. 4. Effect of alkaline-solution to slag ratio on water penetration.

To compare the microscopic structure of alkali activated slag concrete with ordinary concrete, scanning electron microscopy (SEM) images were prepared from both concrete, shown in Figures 6 and 7.

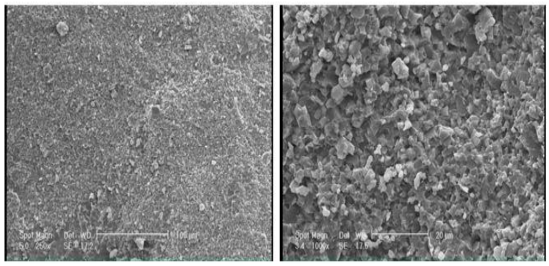

Fig 5. Electron microscope image from the sample of alkali activated slag concrete

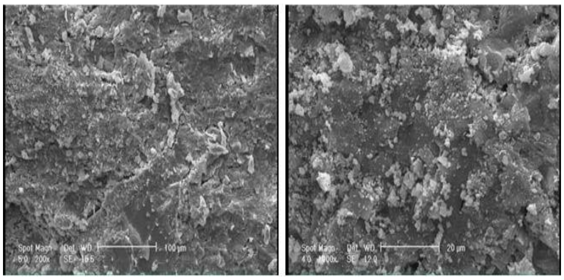

Fig 6. Electron microscope image from the sample of alkali activated slag concrete

3. Conclusion

In this study, the effect of alkaline-solution/slag ratio variation on permeability of alkali activated slag concrete were experimentally examined. AASC and OPCC samples were subjected to a series of tests, including: slump, compressive strength, the initial and total water absorption, the rapid chloride permeability (RCPT) and the water impermeability test. Based on the results obtained it can be concluded that:

1. In all but one test (short-term water absorption), AASC outperformed Portland cement concrete.

2. There is only a slight difference between short-term water absorption and total water absorption of AASC and this can be considered as another positive feature of this type of concrete.

3. Based on the test results, the alkaline-solution/slag ratios of 0.45 and 0.50 are the optimum values for AASC production.

4. Alkali activated slag concrete have more regular and crystalline structure than ordinary concrete.